1987

Evaluation of a hearing conservation program at a large industrial company: comparisons of hearing levels in workers exposed to noise on two different schedules with workers in low-noise areas

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"Evaluation of a hearing conservation program at a large industrial company: comparisons of hearing levels in workers exposed to noise on two different schedules with workers in low-noise areas"

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Independent study
1985-1987

Abstract

This study involved evaluating the hearing conservation program (HCP) of a large industrial company by comparing the audiometric data of two groups of workers. Group 1 was selected from individuals employed in areas where the time-weighted average (TWA) sound level exceeded 90dBA and Group 2 where the TWA was less than 85dBA. Differences between mean STS values for groups and plants were the main criteria used in making judgments on the HCP effectiveness. In addition, age, sex, years of service, and non-occupational noise exposure were evaluated. A significant difference existed in mean STS between the noise and non-noise groups. Both groups exhibited some incidence of STS with a incidence of 34% for the entire population. The male-female distribution, previous hearing loss and non-occupational noise exposure were judged to be contributing factors in the differences that existed between plants and groups. The results of this study are preliminary and further research is needed to make more definite statements.

Introduction:

The primary goal of any hearing conservation program (HCP) is the elimination of noised-induced permanent threshold shift (PTS) resulting from occupational exposure to noise. A systematic method of judging the effectiveness of such a program is essential in realizing this goal. There is a need for an objective procedure to evaluate the success of a program. It has been shown that even though a HCP is well planned and well administered there is no guarentee that the program is really effective. Due to problems in utilizing hearing protection devices (HPDs) and limitations in the degree of protection given by HPDs in real-world environments, the only reliable estimate of the actual protection being provided comes from analyzing the audiometric database (Royster and Royster 1982).

Current evaluation procedures involve the use of audiometric data from individuals in a general working population. Recent research has shown that evaluating the effectiveness of the HCP involves the interaction of several factors, including: 1) Aging effects (presbycusis), 2) Standard threshold shift criteria used, 3) The choice of an appropriate control sample of "non-noised" exposed subjects for comparison to the "noised" exposed sample, and 4) Sex differences among samples.

The objective of this study was to evaluate the effectiveness of a large industrial corporation HCP by comparing the audiometric data from two groups of workers. Group 1 was selected from individuals employed in areas where the time-weighted average (TWA) sound level exceeded 90dBA and Group 2 where the TWA was less than 85dBA.

The Occupational Safety and Health Adminstration (OSHA) developed a definition of standard threshold shift (STS) that is designed to identify employees sustaining progressive losses of hearing and is included in the OSHA Hearing Conservation Amendment of 1983. STS is defined as an average shift of 10dB or more at 2000, 3000, and 4000 Hz relative to the baseline audiogram in either ear. OSHA evaluated over 40 definitions of STS before arriving at a final decision (Miller 1986).

Using OSHA's definition baseline test data and current test data were evaluated for each individual to determine if a STS occurred. The mean STS for each group was derived. The two groups were then compared to each other to determine if a significant difference existed.

Use of the database of a large industrial company gave us the opportunity to take an established HCP and to evaluate the program in a systematic and objective way.

Methods:

Audiometric data for two groups of workers were obtained from a large industrial companies database.[1] Group 1 was a sample of employees working in environments with noise exposure levels of 90dBA and above. Group 2 was a sample of employees with noise exposure levels of 85dBA and below. The groups were carefully selected by the company's HCP administrator so that each group consisted of workers employed in the above environments for a minimum of 10 years. These data were obtained from plants located in three different geograhic locations:1.) Florida 2.) Alabama 3.) South Carolina.

For each employee information pertaining to age, sex , and years of service was obtained from the database. Each employee was also given a number to signify plant, group, and the number of the subject.

subject	age	sex	years
1101*	53	m	30
1102	44	m	21
1103	40	m	22
1104	56	m	29

* 1(plant) 1(group) 01(subject)

FIG 1

Medical history data, obtained from voluntary responses of employees, is summarized in Figure 2. The information that was requested on the medical history form is found in columns 1-4. The number of years engaged in non-occupational noise exposure was recorded in column 5. The findings of the otoscopic examination of each ear was also reported.

MEDICAL HISTORY

column 1	column 2	column 3	column 4	column 5
heredity	**diseases**	**symptoms**	**injuries**	**exposure**
mother	measles	M.D. care	blow to ear	military
father	mumps	draining ears	concussion	artillery
aunts	chicken pox	ear aches	skull fracture	shooting
uncles	scarlet fever	ear surgery	other injury	private fly.
sisters	diabetes	hearing aid	eardrum punc.	loud music
brothers	high fever	excess ear wax	explosion	home tools
daughters	allergies	tinnitus	flying/skydiv.	machinery
sons	menimgitus	face feels numb	auto accident	motor boat
	blood pressre	dizziness	diving accident	other noise
				hearing loss

FIG 2

Finally a complete record of audiometric data was obtained for the frequencies 0.5-8kHz. This information contained baseline, current, and previous test information and also the year each test was administered. Threshold data for the baseline audiogram was not necessarily obtained at time of initial employment. A STS value was calculated for each employee using the criteria established by OSHA (the diference between the average at 2,3,4kHz of the baseline audiogram and the current audiogram). The study involved comparing mean STS values for groups and plants. In addition, age, sex, years of service, and non-occupational noise exposure were also evaluated. The differences between the values were the main criteria used in making judgments on the effectiveness of the HCP.

These judgments on the effectiveness of the HCP are of particular importance for the company. Operating an effective HCP yields the obvious benefit of preventing the employee from sustaining a job-related loss of hearing from noise. In addition, protected workers experience less fatique, fewer on-the-job injuries and less emotional strain as a result of communication difficulties (Royster, Royster, and Berger, 1982). Secondary benefits include an improved employee-employer relationship and a reduction of compensation costs for a noised-induced hearing loss.

Results:

Plant managers of the three plants were asked by the HCP administrator to find employees that met the previously mentioned noise criteria. 413 subjects were carefully chosen so that they had been working in the

specified exposure enviroment for a minimum of ten consecutive years. The sample had a mean age of 45.7±7.3 with 21.1±7.0 years of service.

The data were analyzed for specific information regarding sex, age, and years of service throughout the various plants. The 413 subjects consisted of 306 males and 107 females. The distribution of males and females by plant is presented in Table 1a.

Distribution of males and females

	males	females
p1g1*	48	1
p1g2	43	7
p2g1	76	24
p2g2	69	23
p3g1	23	37
p3g2	26	12
p3g3	21	3
totals		
plant 1	91	8
plant 2	145	47
plant 3	70	52
	306	107

*p= plant
g= group

TABLE 1a.

It is clearly shown that plant 1 has the larger male to female ratio and that plant 3 has the most even distribution of males and females. The distribution by group is also presented in Table 1a.

The mean age within each group by male and female is given in Table 1b. There is no major difference between the average age throughout the

Anova table for a 2-factor Analysis of Variance on Y_1 : Age

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	1438.63	239.772	4.762	.0001
Sex (B)	1	405.36	405.36	8.05	.0048
AB	6	767.913	127.986	2.542	.0199
Error	399	20091.356	50.354		

1

There were no missing cells found.

The AB Incidence table on Y_1 : Age

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	48 44.854	1 23	49 44.408
	p1,g2	43 47.233	7 45	50 46.92
	p2,g1	76 47.263	24 44.542	100 46.61
	p2,g2	69 44.362	23 41.435	92 43.63

2

Page 2 of the AB Incidence table on Y_1 : Age

	Sex:	m	f	Totals:
Recode of Subject	p3,g1	23 47.826	37 48.595	60 48.3
	p3,g2	26 42.885	12 46.583	38 44.053
	p3,g3	21 46.619	3 44.333	24 46.333
Totals:		306 45.853	107 45.327	413 45.717

3

Table 1b

Mean age of subject

1.) For each group

2.) By male and Female

various groups. The mean years of service for males and females for each plant-group was also calculated and the data is shown in Table 2.

Using the medical history data mean values were calculated and grouped by sex to show the number of years engaged in a non-occupational noise exposure activity (Appendix A). This information was later used to determine if non-occupational noise exposure in any way affected mean STS in the various groups.

The audiometric data collected from the database contained baseline, current, and previous test information. The mean baseline year was calculated for the "noise" and "non-noise" exposed groups in each plant. The mean baseline years for the plants were as follows: plant 1 (1967.2); plant 2 (1976.2); and plant 3 (1974.9). These results show that plant 1 has the earlier recorded baseline audiograms in comparison to plants 2 and 3. These results are summarized in Table 3. Similar calculations were made using current and previous test information and presented in Tables 4 and 5.

Mean hearing threshold levels (average in dBHL of 0.5,1,2,3,4,6,8kHz) were calculated for each group in the three plants. The calculations were done for baseline, current, and previous audiometric data. Audiograms display this information for the baseline and current audiometric data in Appendix B. These audiograms show that both the "noise" and "non-noise" exposed groups in all three plants exhibit a classical noise exposure notch at 4-6kHz. This information however, cannot be used to conclude that the notch is a direct result of occupational noise exposure. The possibility of noise exposure outside the workplace or other etiologies must be considered as contributing factors.

subject-sex-years service

Anova table for a 2-factor Analysis of Variance on Y_1 : Years

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Sex (A)	1	189.018	189.018	4.171	.0418
Recode of Subject (B)	6	1238.448	206.408	4.554	.0002
AB	6	781.986	130.331	2.876	.0094
Error	399	18082.942	45.321		

1

There were no missing cells found.

Page 1 of the AB Incidence table on Y_1 : Years

Recode of Sub...		p1,g1	p1,g2	p2,g1	p2,g2	p3,g1	p3,g2
Sex	m	48 22.375	43 23.907	76 22.855	69 18.783	23 20.609	26 18.654
	f	1 3	7 24.714	24 19.667	23 16.565	37 20.432	12 23.75
Totals:		49 21.98	50 24.02	100 22.09	92 18.228	60 20.5	38 20.263

2

Table 2

Mean number of Years of Service

]) For Each Group

2) By Male and Female

Recode of Sub...		p3,g3	Totals:
Sex	m	21 22.429	306 21.454
	f	3 22.667	107 19.981
Totals:		24 22.458	413 21.073

3

One Factor ANOVA X_1 : Recode of Subject Y_1 : Baseline/yr

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	6	6855.525	1142.587	89.852
Within groups	406	5162.805	12.716	p = .0001
Total	412	12018.329		

Model II estimate of between component variance = 186.312

One Factor ANOVA X_1 : Recode of Subject Y_1 : Baseline/yr

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p1,g1	49	1966.592	3.082	.44
p1,g2	50	1967.74	5.178	.732
p2,g1	100	1973.49	3.82	.382
p2,g2	92	1978.815	3.545	.37
p3,g1	60	1974.283	.993	.128

One Factor ANOVA X_1 : Recode of Subject Y_1 : Baseline/yr

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p3,g2	38	1975.789	4.431	.719
p3,g3	24	1974.5	.933	.19

Table 3

Mean Baseline Year for Each Group

One Factor ANOVA X_1: Recode of Subject Y_9: Prev/yr

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	6	116.922	19.487	30.241
Within groups	406	261.62	.644	p = .0001
Total	412	378.542		

Model IIestimate of between component variance = 3.14

65

One Factor ANOVA X_1: Recode of Subject Y_9: Prev/yr

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p1,g1	49	1984.837	.8	.114
p1,g2	50	1984.36	.985	.139
p2,g1	100	1983.86	.792	.079
p2,g2	92	1983.761	.803	.084
p3,g1	60	1985.083	.561	.072

66

One Factor ANOVA X_1: Recode of Subject Y_9: Prev/yr

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p3,g2	38	1984.684	.904	.147
p3,g3	24	1985.083	.776	.158

Table 4

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Mean Previous Year for Each Group

One Factor ANOVA X_1: Recode of Subject Y_{17}: Current year

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	6	68.724	11.454	22.874
Within groups	406	203.3	.501	p = .0001
Total	412	272.024		

Model II estimate of between component variance = 1.826

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One Factor ANOVA X_1: Recode of Subject Y_{17}: Current year

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p1,g1	49	1985.857	1.041	.149
p1,g2	50	1985.54	.788	.111
p2,g1	100	1984.98	.765	.077
p2,g2	92	1985.076	.745	.078
p3,g1	60	1985.9	.303	.039

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One Factor ANOVA X_1: Recode of Subject Y_{17}: Current year

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p3,g2	38	1985.842	.437	.071
p3,g3	24	1986	0	0

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Table 5

Mean Current Year for Each Group

Scattergrams of the baseline hearing threshold levels for each subject in the study are given in Appendix C. These scattergrams are plotted for each frequency(0.5-8kHz) with age of the subject on the abscissa and the HTL for the particular frequency on the ordinate. It can be seen from these graphs that many of the older subjects in the study already had an existing hearing loss at the time of the baseline audiogram

The OSHA definition was the criteria used in identifying individuals having a STS. Each individuals baseline audiogram average was subtracted from the current audiogram average for the frequencies 2,3,4kHz. An average value among subjects was obtained to create a single value for each group within the three plants.

Several calculations were done using the STS data. The calculations were as follows:

1.) The actual number of cases of a STS for each group in the three plants.
2.) The mean STS in all groups.
3.) The incidence of a STS in all groups in the plants.
4.) One-factor anova's to determine if a significant difference existed in the previous calculations between: a) the "noise" and the "non-noise" groups; b.) the "noise" exposed groups in each plant; c.) the "non-noise" exposed groups in each plant; d.) among all plants and groups.

The results given below are a summary of the calculations done in the order that they were previously presented.

The actual number of cases of STS occurring in the three different plants and the groups within the plants were obtained. The results are shown in Fig. 4. The results from Fig. 4 show that plant 3 (46 cases) has the highest actual number of cases of STS. Plant 1 (38 cases) had the next highest with plant 2 (16 cases) having the least.

Number of cases of STS for each plant

plant	total for plant>=10	#subjects in plant
plant 1	38	99
plant 2	16	192
plant 3	46	122

totals: 100 out of 413 with STS >= 10

FIG. 4

The mean threshold shift values (the diference between the average at 2,3,4kHz of the baseline audiogram and the current audiogram) for each group and the plants are given in Tables 6 and 7 for the left and right ears. It can be seen by the results in these tables that plant 1 (7.6±11.9LE, 6.8±11.1RE) and plant 3 (6.9±9.2LE, 6.9±8.1RE) have the highest mean threshold shift with plant 2 (.35±6.6LE, .24±8.9RE) having the lowest. In these graphs a positive number represents a deterioration in hearing sensitivity while a negative number indicates the hearing sensitivity has improved. Group 1 (the workers in the "noise" exposed environments) had a larger mean threshold shift than Group 2 ("non-noise" exposed environment) in all three plants.

The incidence of STS is given in Table 8, for the three plants and for the exposed and non-exposed samples. This table clearly shows that plant 3 (56%) has the highest incidence of STS and that plant 2 (13%) has the lowest. In all the plants Group 1 (p1=59%, p2=22%, p3:g1=53%,g3=75%) has the higher incidence than Group 2 (p1=40%, p2=4%, p3=39%). It is interesting to note that the "non-noise" exposed groups report some incidence of STS.

The next calculations were done to determine if a significant difference existed in mean STS between: 1.) the exposed and non-exposed groups; 2.) the exposed groups between the three plants; 3.) the non-exposed groups in all plants; 4.) among all plants and groups. The first calculation between the exposed and non-exposed groups was one of the most important calculations made. This calculation was the main criteria used for making a judgment on the effectiveness of the HCP in preventing hearing loss due to occupational noise exposure. We originally hypothesized that if a significant difference did exist between the two groups that the program

plant-sex-std thres shft right

Anova table for a 2-factor Analysis of Variance on Y_1 : std thr sft right

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	2921.301	486.884	7.058	.0001
Sex (B)	1	266.992	266.992	3.87	.0498
AB	6	398.49	66.415	.963	.4502
Error	396	27316.827	68.982		

1

There were no missing cells found.

The AB Incidence table on Y_1 : std thr sft right

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	47 9	1 0	48 8.812
	p1,g2	43 5.566	6 -.889	49 4.776
	p2,g1	76 1.465	24 -1.903	100 .657
	p2,g2	68 -.593	23 .913	91 -.212

2

Table 6
The mean STS value

1.) For each Group

2.) By Males and Females

Recode of Subject	p3,g1	23 8.406	37 6.396	60 7.167
	p3,g2	26 5.385	12 3.472	38 4.781
	p3,g3	21 10.159	3 8.889	24 10
Totals:		304 4.211	106 2.594	410 3.793

3

plant-sex-std thres shft left

Anova table for a 2-factor Analysis of Variance on Y_1 : std thr sft lft

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	3421.46	570.243	7.461	.0001
Sex (B)	1	396.372	396.372	5.186	.0233
AB	6	413.268	68.878	.901	.494
Error	397	30344.548	76.435		

1

There were no missing cells found.

The AB Incidence table on Y_1 : std thr sft lft

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	48 10.181	1 0	49 9.973
	p1,g2	43 5.837	6 .056	49 5.129
	p2,g1	76 1.618	24 -2.389	100 .657
	p2,g2	68 .01	23 .043	91 .018

2

Table 7

The mean STS value

1.) For each Group

2.) By Males and Females

	Sex:	m	f	Totals:
Recode of Subject	p3,g1	23 9.058	37 7.838	60 8.306
	p3,g2	26 5.769	12 -.417	38 3.816
	p3,g3	21 8.413	3 8.333	24 8.403
Totals:		305 4.585	106 2.396	411 4.02

3

One Factor ANOVA X_1 : Recode of Subject Y_1 : Recode of Incidence of STS

Analysis of Variance Table

Source:	DF:	Sum Squares:	Mean Square:	F-test:
Between groups	6	19.255	3.209	17.763
Within groups	405	73.172	.181	p = .0001
Total	411	92.427		

Model II estimate of between component variance = .505

One Factor ANOVA X_1 : Recode of Subject Y_1 : Recode of Incidence of STS

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p1,g1	49	.592	.497	.071
p1,g2	49	.408	.497	.071
p2,g1	100	.22	.416	.042
p2,g2	92	.043	.205	.021
p3,g1	60	.533	.503	.065

One Factor ANOVA X_1 : Recode of Subject Y_1 : Recode of Incidence of STS

Group:	Count:	Mean:	Std. Dev.:	Std. Error:
p3,g2	38	.395	.495	.08
p3,g3	24	.75	.442	.09

Table 8

Incidence of STS

1.) For each group

* Based on whole population

was not effective. The absence of a significant difference between the two groups would mean the program was effective. This statement is important to keep in mind throughout the presentation of the results.

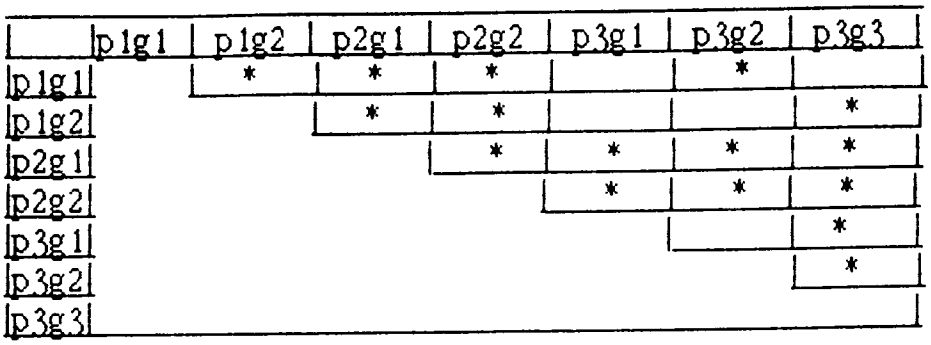
Results from one-factor Anova's for determining if a significant difference existed between the exposed and the non-exposed groups is shown in Figures 6 and 7. These figures show that a significant difference in mean STS exists between the exposed and non-exposed samples in plants 1 and 3 but not in plant 2. There was (as can be seen by the figures) a significant difference in mean STS between the noise exposed groups in plants 1 and 2, and 2 and 3. There was no significant difference however between plants 3 and 1. There was a significant difference between the non-exposed in mean STS in plants 1 and 2 and plants 2 and 3.

Next a comparison of incidence of STS was calculated for the groups within the plants and among plants. One-factor anova's were again used and the results are shown in Fig. 5. The following results can be utilized from this figure: 1.) A significant difference exists in incidence of STS between the exposed and non-exposed groups in all plants; 2.) A significant difference exists in incidence between the exposed groups in plants 1 and 2 and plants 2 and 3; 3.) A significant exists between the non-exposed groups between plants 1 and 2 and plants 2 and 3.

Discussion:

This initial analysis of the data shows that significant differences exist 1.) between the exposed and non-exposed samples 2.) between the samples in each plant. These results, specifically for the noise and non-noise exposed samples do not allow us to make the judgment that the HCP

Incidence of STS



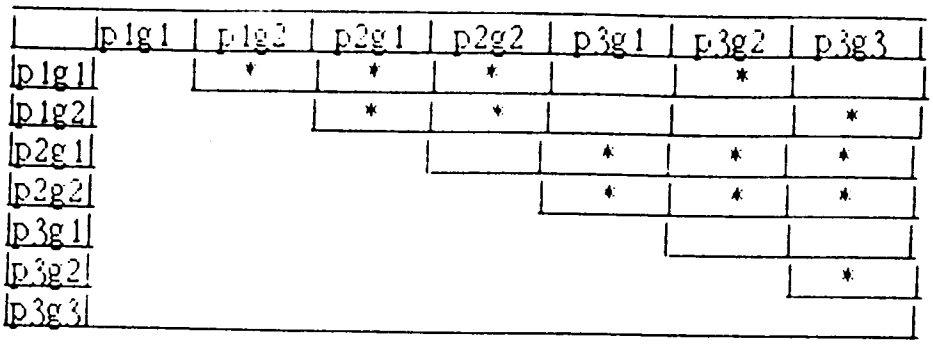
* one-factor anova (significant at 95%)

FIG 5

Comparison of the groups for incidence

* in the cell indicates a significant difference in incidence between the groups

STS (current minus baseline) RE



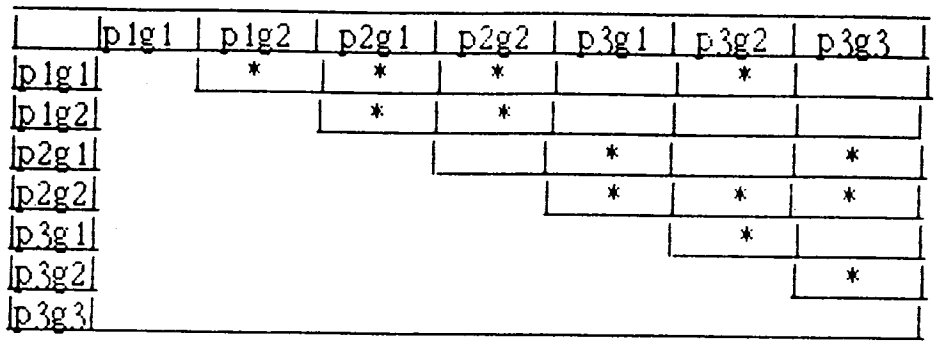
* one-factor anova (significant at 95%)

FIG 6

Comparison of the groups for mean threshold shift in the right ear

* in the cell indicates a significant difference in mean threshold shift between the groups

STS (current minus baseline) LE



* one-factor anova (significant at 95%)

FIG 7

Comparison of the groups for mean threshold shift in the left ear

in the different plants is effective in preventing hearing loss due to occupational noise exposure. This is based on our criteria for judging the effectiveness of a HCP. We can not say however, that these differences are a direct result of occupational noise exposure. Factors such as age, sex, previous hearing loss, and non-occupational noise exposure must be considered.

The first of these to be analyzed was the distribution of age among the plants. The mean age was calculated for each group and no significant difference was found to exist among the the plants. These results have been previously presented. We therefore concluded that age was not a significant contributing factor.

The data obtained for the distribution of males and females were re-analyzed to see if this could possibly be a contributing factor. The data did show that plant 1 (91 to 8) had a much larger ratio of males to females. Plant 2 (145 to 47) had the next largest, while plant 3 (70 to 52) had a more even distribution. Research has shown that males experience a greater threshold shift as a result of noise exposure than do females (Royter and Royster, 1980). The large number of males compared to the small number of females in plant 1 could be a possible contributing factor in the higher mean STS and incidence. We felt however that sex was not a contributing factor for plant 3 because the number of males and females was evenly distributed.

The mean number of years of service was also calculated and found to be evenly distributed and judged not to be an important factor.

Those who reported hearing loss in their medical history were deleted from the sample in all three plants. Plant 1 was the the only plant that was significantly affected, in that, the mean STS dropped a significant amount

for the plant, from 7.6±11.9 to 1.9±7.5 for the left ear and 6.8±11.1 to 1.3±7.4 for the right ear.

Noise exposure outside the workplace was considered to be a possible contributing factor in the differences between the plants in incidence and mean STS. The mean number of years of each item under the exposure catergory in the medical history was calculated and compared for the three plants. The results are given in Table 9. The results show that plant 1 (s=14.5±13.7, m=9.7±12.5) had a higher degree of exposure to shooting(s) and machinery(m) than did plant 2 (s=6.1±11.4, m=2.9±7.4) and plant 3 (s=2.9±8.5, m=3.9±8.9). There was no significant differences between plants in years of military service, hometool use, and motorboat use. Further analysis also revealed that the exposed group had a higher degree of exposure to all the non-occupational exposure items than did the non-exposed groups in all the plants except plant 2. Mean STS values are recorded in Table 10, showing the values when the subjects with any history of exposure to the non-occupational activity are deleted from the sample.

The analysis and summary of all the previous data allow us to make the following statements:

1.) There is a significant difference between the noise and non-noise exposed groups in mean standard threshold shift. Our method of evaulating the effectiveness of the HCP can not allow us to state that the program is effective. The analysis we have done so far does not allow us to conclude what is the exact cause of the significant differences we dicovered in this study.

2.) All groups ("noise" and "non-noise") exhibit some incidence of STS. This could be due to several factors: a.) Some subjects had been

Mean years non-occupational noise exposure

	Plant 1	Plant 2	Plant 3
military	1.616/2.452*	1.896/2.962	1.615/2.905
shooting	14.485/13.736	6.12/11.409	2.943/8.512
hometools	12.576/10.159	11.078/12.701	6.664/10.339
machinery	9.747/12.543	2.917/7.369	3.893/8.872
motorboat	5.859/9.308	5.589/9.199	3.697/7.772
other	1.333/4.252	10.036/11.403	12.279/10.874

*mean/standard deviation

TABLE 9

Mean STS without certain non-occupational noise exposure

		shooting	hometools	machinery	other
p1g1[1]	RE	8.22/10.442[2]	11.5/9.41	8.853/11.952	9.537/12.134
	LE	8.0/13.512	11.974/12.796	10.333/13.064	9.865/13.065
p1g2	RE	3.792/10.058	3.78/8.563	2.453/7.979	3.891/9.281
	LE	2.556/7.819	6.33/10.167	3.067/8.572	4.299/10.339
p2g1	RE	.272/8.82	-.141/8.745	.928/9.085	-4.5/.707
	LE	.349/8.567	-.548/7.781	.783/8.069	-7.0/1.886
p2g2	RE	.133/3.596	.079/4.177	-2.44/4.299	-.083/4.564
	LE	.311/4.48	-.317/4.448	-.073/4.822	.345/4.595
p3g1	RE	6.358/8.28	7.197/8.61	8.033/8.913	all subjects
	LE	7.716/9.827	7.689/9.151	8.833/10.483	eliminated
p3g2	RE	4.427/7.015	5.317/6.945	4.389/6.872	5.805/6.052
	LE	2.708/7.546	2.063/8.415	3.944/8.31	3.506/7.59
p3g3	RE	9.352/7.097	10.5/6.761	9.314/6.563	7.381/5.998
	LE	10.093/6.454	9.833/4.743	9.902/4.657	8.333/4.907

[1]plant-group
[2]mean/standard deviation

TABLE 10

employed several years prior to the implementation of the HCP; b.) The existence of an older population with hearing loss present at the time of baseline audiogram; c.) That both groups experience noise exposure other than the workplace; d.) The "non-noise" environment is experiencing some occupational noise exposure while on-the-job.

3.) The mean incidence of STS for the entire population is 34% with a standard deviation of 47%.

4.) Non-occupational noise exposure was a contributing factor in the differences seen between the plants in incidence of STS and mean STS.

5.) Male and female distribution should be considered a possible contributing factor in incidence and mean STS differences between plants and groups.

6.) Previous hearing loss in some plants could be considered a factor in creating a higher mean STS in some plants; therefore causing a significant difference to exist between the plants.

Before further conclusions can be drawn about the differences in incidence and mean STS among the groups and plants further analysis should be conducted. This analysis should include: 1.) Complete noise measurements of the noise environments for each group; 2.) Information pertaining to the adminstrative and management techniques of each plant should be evaluated. This evaluation should include educational programs and types and use of proper hearing protection devices. By combining this additional information with data already collected a more conclusive statement about the cause of the differences uncovered in this study can be arrived at.

This study involved the evaluation of a large quanity of data in a short period of time. The findings from this study should be considered as

preliminary. Further research is needed to make more accurate and definite statements as to the effectiveness of the hearing conservation program.

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APPENDIX A

Anova table for a 2-factor Analysis of Variance on Y_1 : Mil. exp.

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	64.725	10.788	1.615	.1416
Sex (B)	1	158.441	158.441	23.717	.0001
AB	6	64.725	10.788	1.615	.1416
Error	399	2665.548	6.681		

1

There were no missing cells found.

The AB Incidence table on Y_1 : Mil. exp.

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	48 2.021	1 0	49 1.98
	p1,g2	43 1.465	7 0	50 1.26
	p2,g1	76 2.579	24 0	100 1.96
	p2,g2	69 2.435	23 0	92 1.826

2

Page 2 of the AB Incidence table on Y_1 : Mil. exp.

	Sex:	m	f	Totals:
Recode of Subject	p3,g1	23 4.174	37 0	60 1.6
	p3,g2	26 1.077	12 0	38 .737
	p3,g3	21 3.476	3 0	24 3.042
Totals:		306 2.356	107 0	413 1.746

3

The mean number of years of military service for each group in the three plants according to the number of males and females.

Anova table for a 2-factor Analysis of Variance on Y_1 : Shooting

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	688.332	114.722	.966	.4478
Sex (B)	1	1826.003	1826.003	15.378	.0001
AB	6	1007	167.833	1.413	.208
Error	399	47378.607	118.743		

There were no missing cells found.

1

The AB Incidence table on Y_1 : Shooting

Recode of Subject	Sex:	m	f	Totals:
	p1,g1	48 16.875	1 0	49 16.531
	p1,g2	43 14.512	7 0	50 12.48
	p2,g1	76 9.289	24 .25	100 7.12
	p2,g2	69 5.681	23 3.087	92 5.033

2

Page 2 of the AB Incidence table on Y_1 : Shooting

Recode of Subject	Sex:	m	f	Totals:
	p3,g1	23 5.435	37 .162	60 2.183
	p3,g2	26 2.808	12 0	38 1.921
	p3,g3	21 7.381	3 0	24 6.458
Totals:		306 9.428	107 .776	413 7.186

The mean number of years of shooting for each group in the three plants according to the number of males and females.

Anova table for a 2-factor Analysis of Variance on Y_1 : Home tools

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	417.286	69.548	.635	.7022
Sex (B)	1	3416.898	3416.898	31.2	.0001
AB	6	480.68	80.113	.732	.6245
Error	399	43697.438	109.517		

There were no missing cells found.

1

The AB Incidence table on Y_1 : Home tools

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	48 12.562	1 0	49 12.306
	p1,g2	43 14.465	7 2.857	50 12.84
	p2,g1	76 15.776	24 .667	100 12.15
	p2,g2	69 12.855	23 1.087	92 9.913

2

Page 2 of the AB Incidence table on Y_1 : Home tools

	Sex:	m	f	Totals:
Recode of Subject	p3,g1	23 10.261	37 2.405	60 5.417
	p3,g2	26 9	12 0	38 6.158
	p3,g3	21 12.095	3 0	24 10.583
Totals:		306 13.186	107 1.402	413 10.133

z

The mean number of years of hometool use for each group according to the number of males and females.

Anova table for a 2-factor Analysis of Variance on Y_1 : machinery

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	356.014	59.336	.717	.6358
Sex (B)	1	839.952	839.952	10.154	.0016
AB	6	786.024	131.004	1.584	.1504
Error	399	33004.863	82.719		

There were no missing cells found.

1

The AB Incidence table on Y_1 : machinery

Recode of Subject	Sex:	m	f	Totals:
	p1,g1	48 9.958	1 0	49 9.755
	p1,g2	43 11.326	7 0	50 9.74
	p2,g1	76 5.342	24 .042	100 4.07
	p2,g2	69 1.638	23 1.739	92 1.663

2

Page 2 of the AB Incidence table on Y_1 : machinery

Recode of Subject	Sex:	m	f	Totals:
	p3,g1	23 6.391	37 1.297	60 3.25
	p3,g2	26 3.885	12 2.75	38 3.526
	p3,g3	21 6.952	3 0	24 6.083
Totals:		306 6.137	107 1.14	413 4.843

3

The mean number of years of machinery use for each group according to males and females.

Anova table for a 2-factor Analysis of Variance on Y_1 : motor boat

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	178.343	29.724	.412	.8712
Sex (B)	1	774.862	774.862	10.733	.0011
AB	6	541.416	90.236	1.25	.2798
Error	399	28805.139	72.193		

1

There were no missing cells found.

The AB Incidence table on Y_1 : motor boat

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	48 6.146	1 0	49 6.02
	p1,g2	43 6.628	7 0	50 5.7
	p2,g1	76 9.013	24 1.125	100 7.12
	p2,g2	69 4.565	23 2	92 3.924

2

Page 2 of the AB Incidence table on Y_1 : motor boat

	Sex:	m	f	Totals:
Recode of Subject	p3,g1	23 7.783	37 .351	60 3.2
	p3,g2	26 2.962	12 2.667	38 2.868
	p3,g3	21 7.143	3 0	24 6.25
Totals:		306 6.49	107 1.103	413 5.094

3

The mean number of years of motor boat use for each group accordingto males and females.

Anova table for a 2-factor Analysis of Variance on Y_1 : other

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	23157.515	3859.586	98.888	.0001
Sex (B)	1	.488	.488	.013	.911
AB	6	177.394	29.566	.758	.6037
Error	399	15572.959	39.03		

1

There were no missing cells found.

The AB Incidence table on Y_1 : other

Recode of Subject	Sex:	m	f	Totals:
	p1,g1	48 1.729	1 0	49 1.694
	p1,g2	43 1.14	7 0	50 .98
	p2,g1	76 18.803	24 17.833	100 18.57
	p2,g2	69 .957	23 .174	92 .761

2

Page 2 of the AB Incidence table on Y_1 : other

Recode of Subject	Sex:	m	f	Totals:
	p3,g1	23 20.435	37 21.838	60 21.3
	p3,g2	26 2.231	12 .5	38 1.684
	p3,g3	21 5.762	3 11.667	24 6.5
Totals:		306 7.438	107 11.972	413 8.613

3

The mean number of years of other exposure for each group according to males and females.

plant-sex-hearing loss

Anova table for a 2-factor Analysis of Variance on Y_1 : Hearing loss

Source:	df:	Sum of Squares:	Mean Square:	F-test:	P value:
Recode of Subject (A)	6	1561.734	260.289	5.605	.0001
Sex (B)	1	66.921	66.921	1.441	.2307
AB	6	1118.278	186.38	4.013	.0006
Error	399	18529.067	46.439		

1

There were no missing cells found.

The AB Incidence table on Y_1 : Hearing loss

	Sex:	m	f	Totals:
Recode of Subject	p1,g1	48 13.792	1 21	49 13.939
	p1,g2	43 13.581	7 0	50 11.68
	p2,g1	76 3.395	24 2.458	100 3.17
	p2,g2	69 1.29	23 1.696	92 1.391

2

Page 2 of the AB Incidence table on Y_1 : Hearing loss

	Sex:	m	f	Totals:
Recode of Subject	p3,g1	23 1	37 1.27	60 1.167
	p3,g2	26 4.038	12 0	38 2.763
	p3,g3	21 .524	3 0	24 .458
Totals:		306 5.66	107 1.551	413 4.596

3

The mean number of years of hearing loss for each group according to males and females.

APPENDIX B

CENTRAL INSTITUTE FOR THE DEAF

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Name: Plant] Group] Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Baseline Left

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Group]

○ = Group 2

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:						Calibration:			
WEBER lateralized to the									

COMMENTS Group]= Exposed Group

Group 2= Unexposed Group

FOOTNOTES

[1] All records were considered confidential and adhere to the regulation " Access to Employee Exposure and Medical Records"

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group] Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Baseline left

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Group]

○ = Group 2

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	_____ daPa	_____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:						Calibration:			
WEBER lateralized to the									

COMMENTS Group] Exposed Group

Group 2 Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group] Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: Group 3

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Baseline Left

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ : Group]

○ : Group 2

△ : Group 3

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:				Calibration:				
WEBER lateralized to the								

COMMENTS Group Group

Group] = Exposed Group

Group 2 = Unexposed Group

Group 3 = Exposed Group

CENTRAL INSTITUTE FOR THE DEAF

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Name: Plant 1 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Current Left

LEGEND

		Right	Left
Air	Unmasked	○	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Group 1
○ = Group 2

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	_____ daPa	_____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:	
	Masking in right:	
Bone:	Masking in left:	
	Masking in right:	

Type of masking: Calibration:

WEBER lateralized to the

COMMENTS Plant - Group 1- Exposed Group

Group 2- Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Current Left

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ - Group 1

○ - Group 2

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	_____ daPa	_____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS Group 1 - Exposed Group

Group 2- Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: Group 3

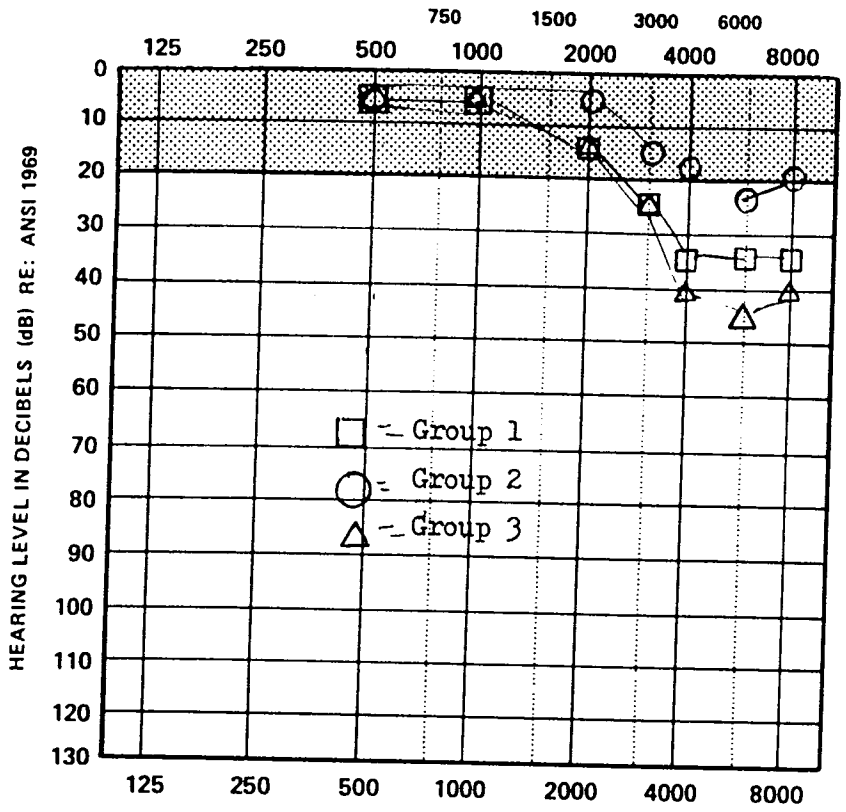
LEGEND Current Left

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY



TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							

Type of masking: Calibration:

WEBER lateralized to the

COMMENTS

Group 1 Exposed Group

Group 2 Unexposed Group

Group 3 EXposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 1 Group 1 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Left Ear

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ : Baseline
○ : Previous
△ : Current

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:						Calibration:			
WEBER lateralized to the									

COMMENTS

_____

_____

_____

_____

_____

_____

_____

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 1 Group 2 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Left Ear

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Baseline
○ = Previous
△ = Current

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS

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CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 1 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Left Ear

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	Δ	□
	Evoked response	●	⧗
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Baseline
○ = Previous
Δ = Currant

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS

_____

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CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 2 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

LEGEND

		Right	Left
Air	Unmasked	○	×
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Left Ear

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Baseline
○ = Previous
△ = Current

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:					Calibration:				
WEBER lateralized to the									

COMMENTS _____

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 1 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Left ear

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Baseline
○ = Previous
△ = Current

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
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SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:						Calibration:			
WEBER lateralized to the									

COMMENTS

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 2 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	Δ	□
	Evoked response	●	▼
	Soundfield	S	
Bone	Unmasked	<	>
	Masked	[	]

Left Ear

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□: Baseline
O: Previous
Δ: Current

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
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EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							

Type of masking: Calibration:

WEBER lateralized to the

COMMENTS _____

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 3 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____
Speech: _____

Left Ear

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

Baseline
Previous
Current

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	_____ daPa	_____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS

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CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 1 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Baseline Right

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

750 1500 3000 6000

125 250 500 1000 2000 4000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ : Group 1

○ : Group 2

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	_____ daPa	_____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left.							
	Masking in right:							
Bone:	Masking in left.							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS Group 1 - Exposed Group

Group 2 - Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Baseline Right

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	Δ	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ = Group 1

○ = Group 2

TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	_____ daPa	_____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
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SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:								Calibration:	
WEBER lateralized to the									

COMMENTS Group 1 - exposed Group

Group 2 - Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech Group 3

Baseline Right

LEGEND

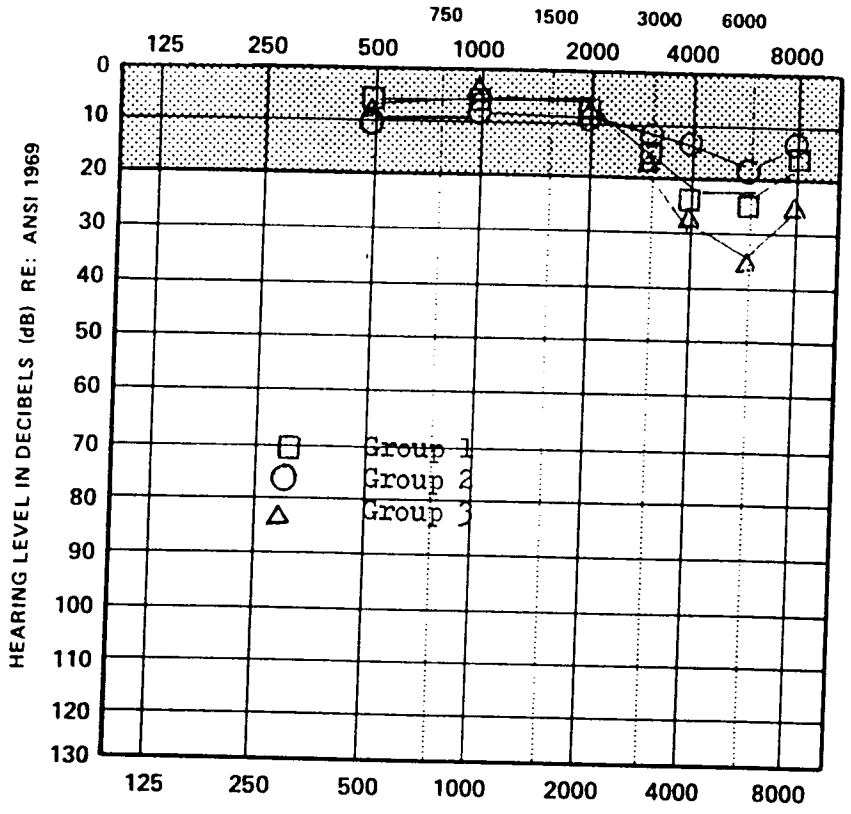
		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	S	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)



TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
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SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							

Type of masking: Calibration:

WEBER lateralized to the

COMMENTS

Group 1 - Exposed Group

Group 2 - Unexposed Group

Group 3 - Exposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 1 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Current: Right

LEGEND

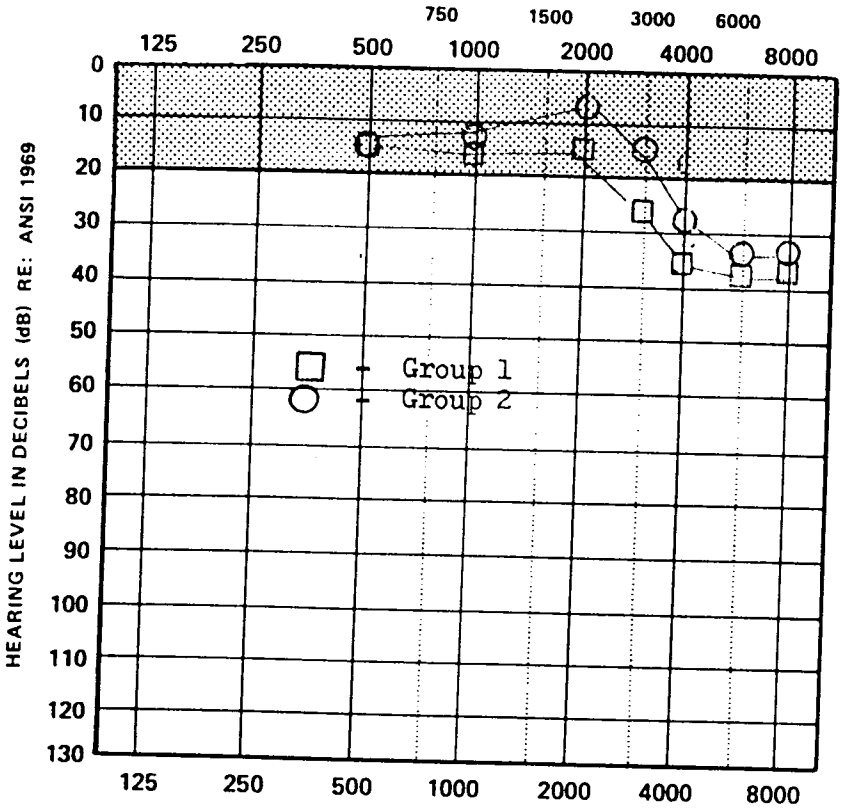
		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	⧗
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)



TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
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SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS Group 1 - Exposed Group

Group 2 - Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: _____

Cur rent Right

LEGEND

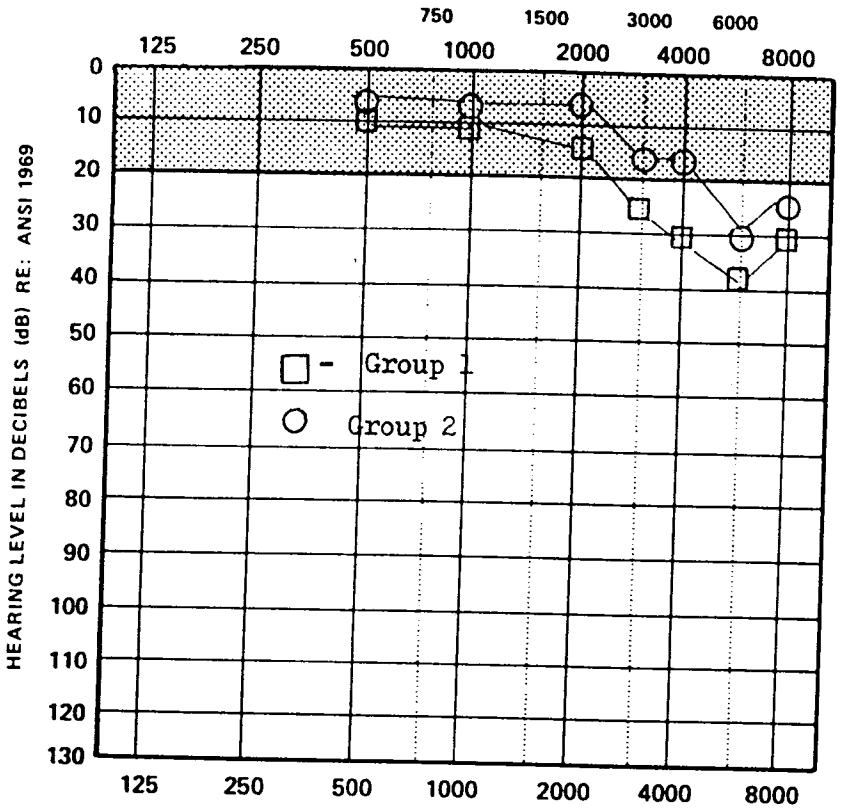
		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	⧗
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)



TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
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SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS Group 1- Exposed Group

Group 2- Unexposed Group

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 1 Date: _____ Age: _____

Audiometer [Tones: Group 2 Sex: ____ Examiner: _____

Speech: Group 3

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	⧗
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

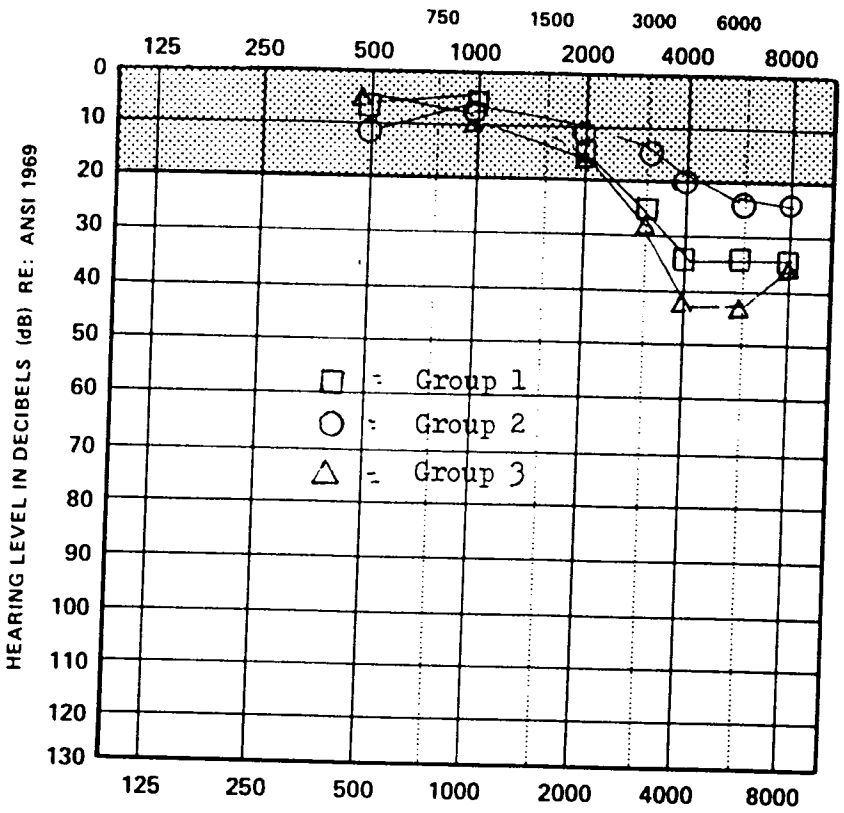
Current Right

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)



TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
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Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:				Calibration:				
WEBER lateralized to the								

COMMENTS _____

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 1 Group 1 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Right

LEGEND

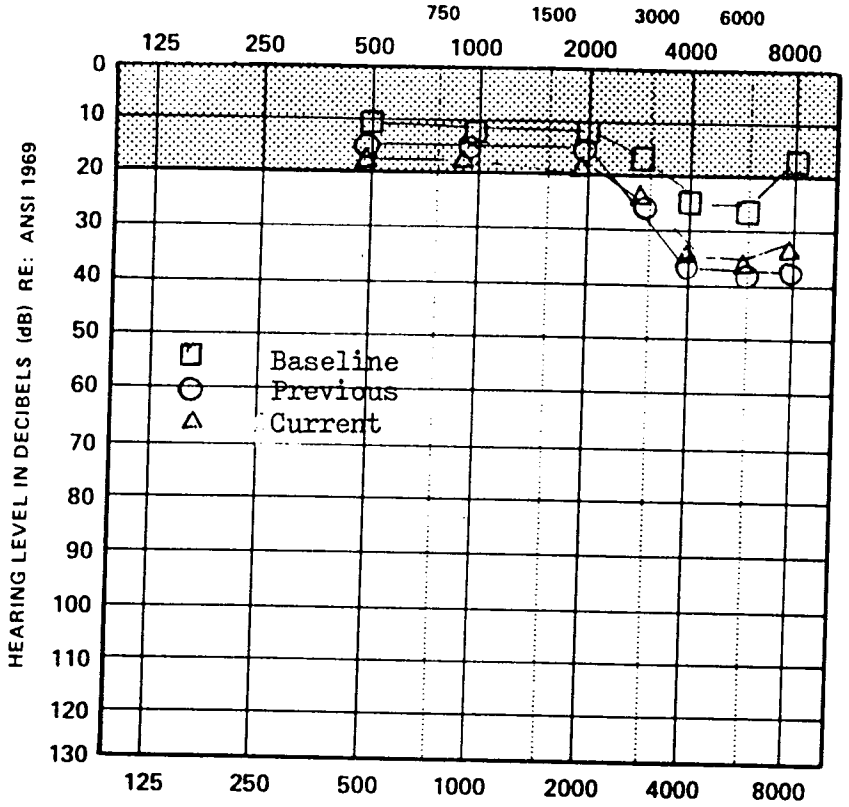
		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)



TYMPANOMETRY

	Right	Left
Static values		
Peak pressure	____ daPa	____ daPa
Configuration		

ABBREVIATIONS

NR	no response
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UCL	uncomfortable level
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Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS _____

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 1 Group 2 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Right

LEGEND

		Right	Left
Air	Unmasked	○	×
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

Baseline = □

Previous = ○

Current = △

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
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Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							

Type of masking: Calibration:

WEBER lateralized to the

COMMENTS

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 1 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Right

LEGEND

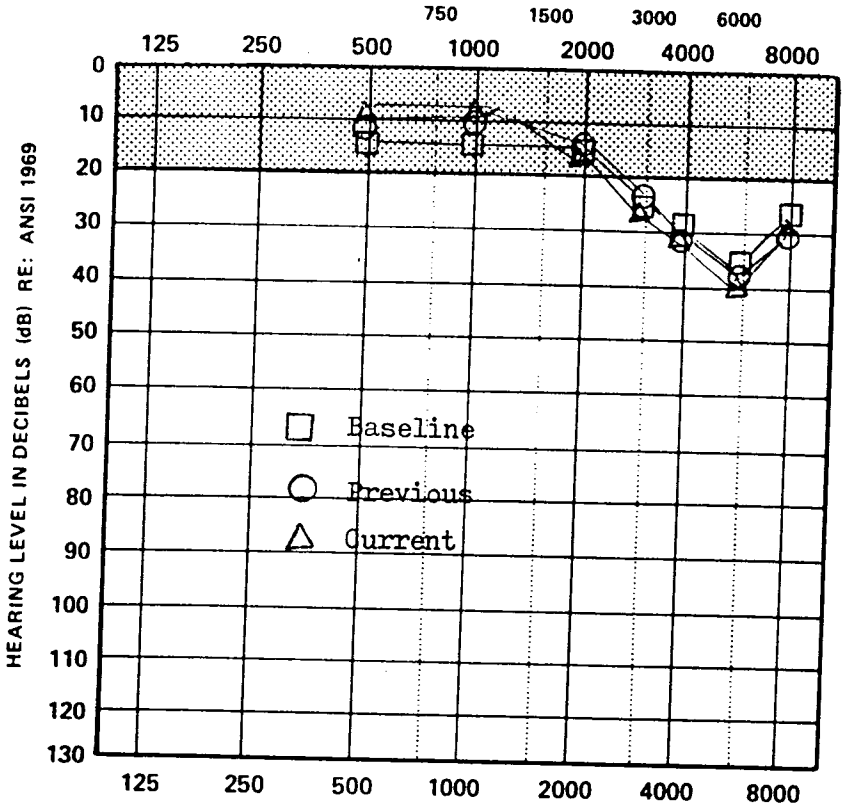
		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	S	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency: good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq.		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)



TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
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UCL	uncomfortable level
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Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS

_____

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CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 2 Group 2 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Right

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

□ Baseline

○ Previous

△ Current

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
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MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS

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CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 1 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

LEGEND Right

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield		$
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq.		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

Baseline □

Previous ○

Current △

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
SPL	sound pressure level
HL	hearing level
EM	effective masking level
SAT	speech awareness threshold
SRT	speech reception threshold
MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:					Calibration:				
WEBER lateralized to the									

COMMENTS

_____

_____

_____

_____

_____

_____

_____

CENTRAL INSTITUTE FOR THE DEAF

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Name: Plant 3 Group 2 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Right

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	▼
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

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Baseline □

Previous ○

Current △

TYMPANOMETRY

	Right	Left
Static values	_____	_____
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MLV	monitored live voice

Air:	Masking in left:							
	Masking in right:							
Bone:	Masking in left:							
	Masking in right:							
Type of masking:		Calibration:						
WEBER lateralized to the								

COMMENTS

_____

_____

_____

_____

_____

_____

_____

CENTRAL INSTITUTE FOR THE DEAF

818 So. EUCLID • ST. LOUIS, MO 63110

Name: Plant 3 Group 3 Date: _____ Age: _____

Audiometer [Tones: _____ Sex: ____ Examiner: _____

Speech: _____

Right

LEGEND

		Right	Left
Air	Unmasked	O	X
	Masked	△	□
	Evoked response	●	⧗
	Soundfield	$	
Bone	Unmasked	<	>
	Masked	[	]

Response consistency good fair poor

AVERAGE (500-2000 Hz) in dB	Right	Left
Two freq		
Three freq		

AUDIOMETRY

FREQUENCY IN HERTZ (Hz)

125 250 500 750 1000 1500 2000 3000 4000 6000 8000

HEARING LEVEL IN DECIBELS (dB) RE: ANSI 1969

0 10 20 30 40 50 60 70 80 90 100 110 120 130

Baseline - □

Previous - ○

Current - △

TYMPANOMETRY

	Right	Left
Static values	_____	_____
Peak pressure	_____ daPa	_____ daPa
Configuration	_____	_____

ABBREVIATIONS

NR	no response
DNT	did not test
SL	sensation level
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MCL	most comfortable level
UCL	uncomfortable level
MLV	monitored live voice

Air:	Masking in left:								
	Masking in right:								
Bone:	Masking in left:								
	Masking in right:								
Type of masking:									
Calibration:									
WEBER lateralized to the									

COMMENTS

_____

_____

_____

_____

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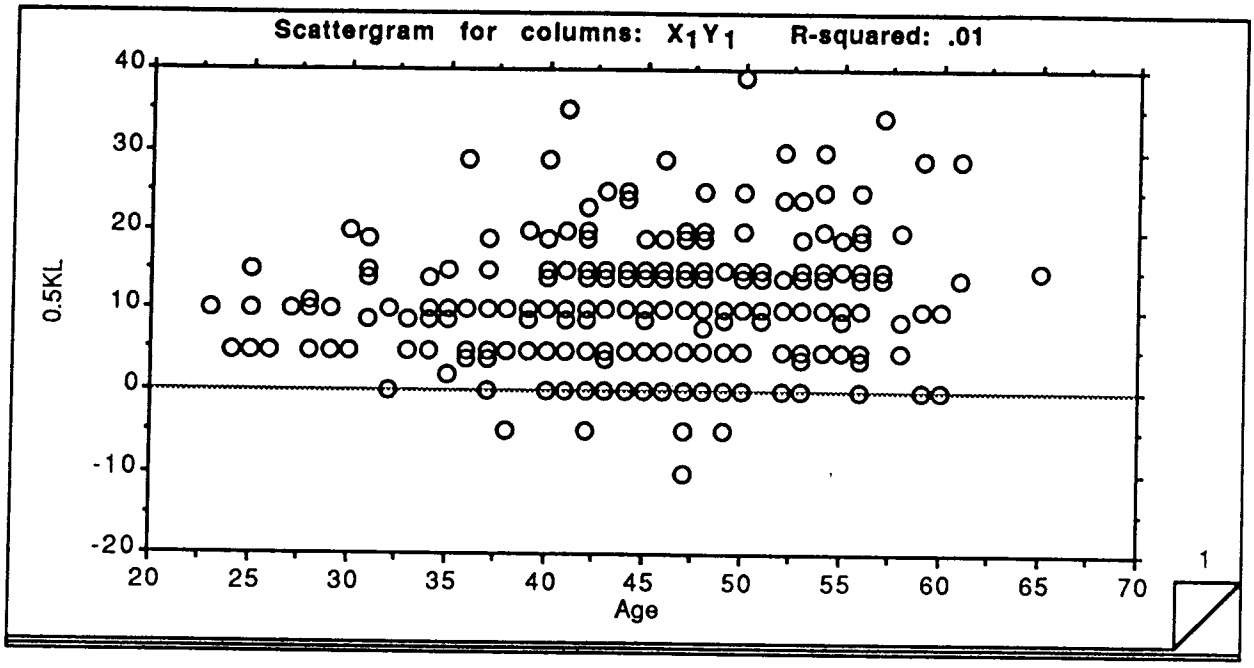
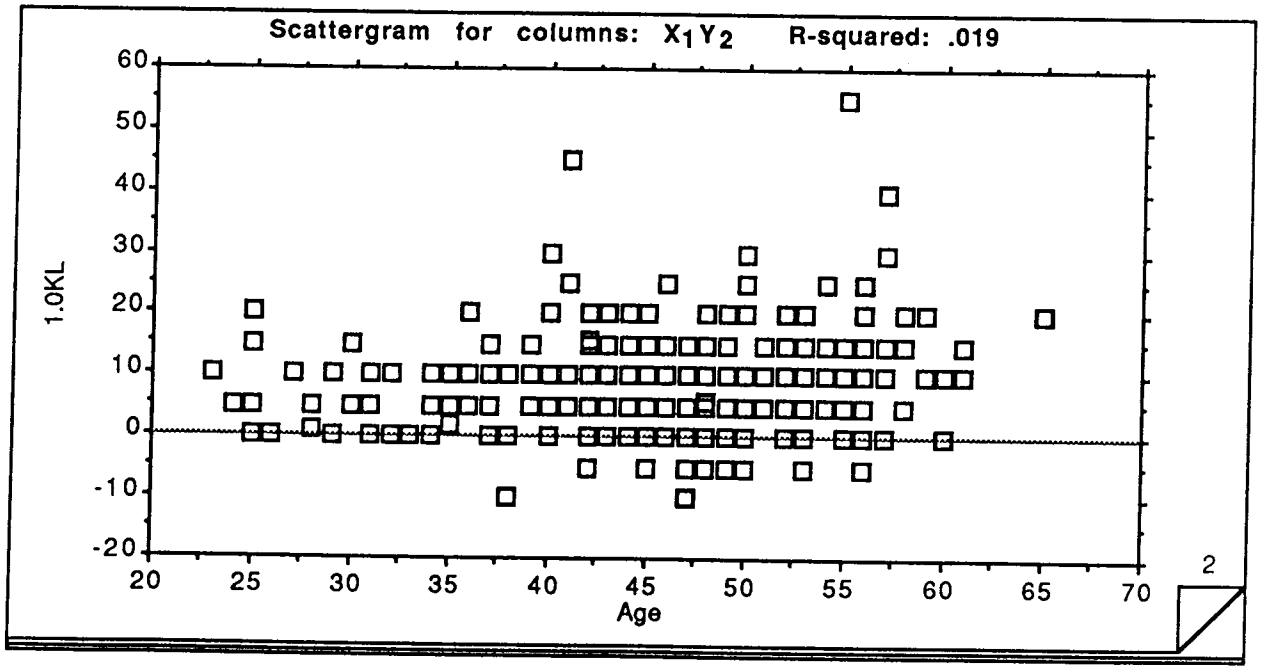
_____

_____

APPENDIX C





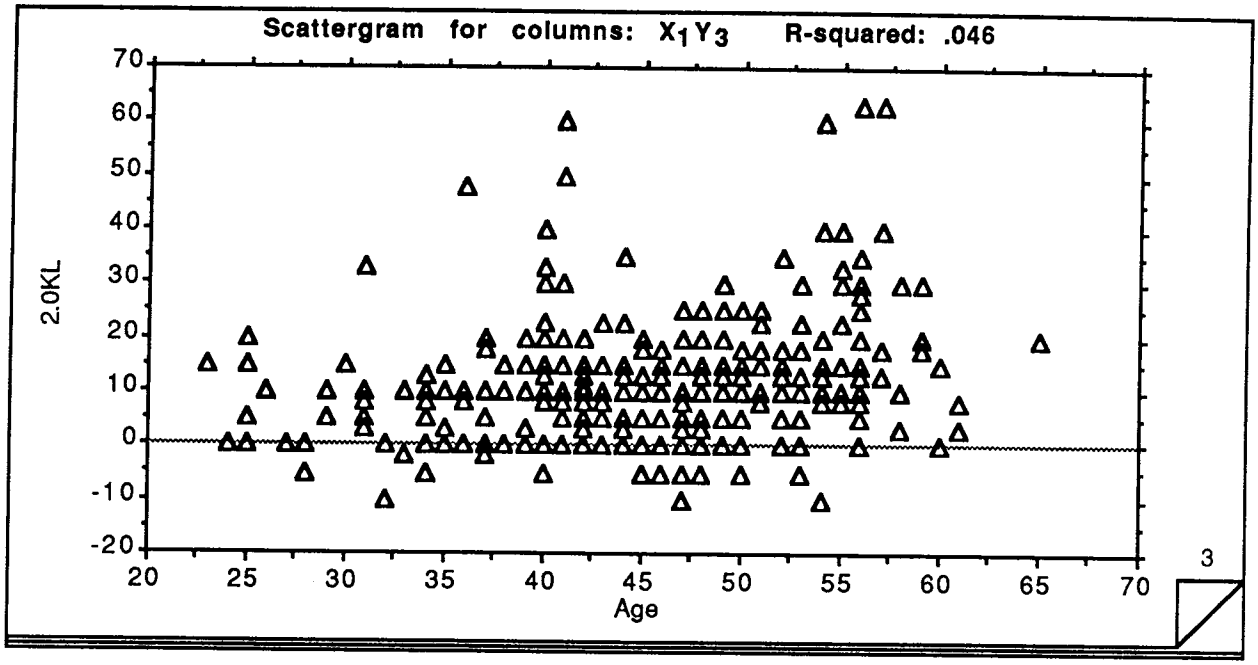
Scattergrams

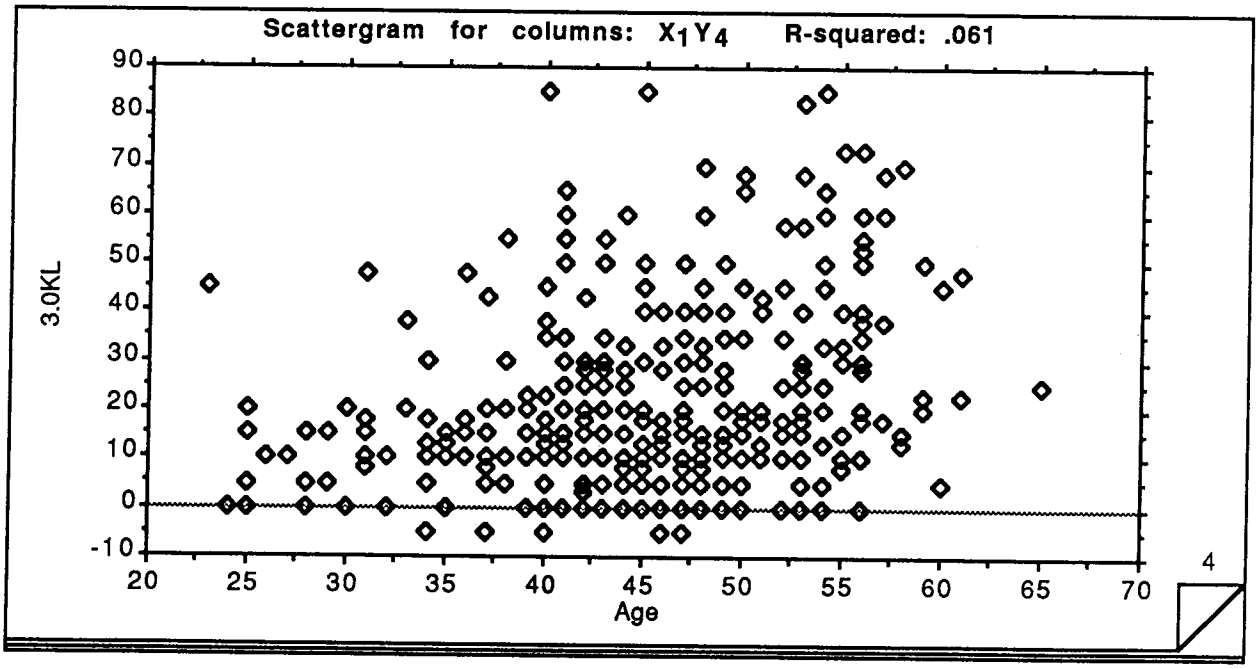
Hearing threshold levels for each frequency for all subjects according to age.

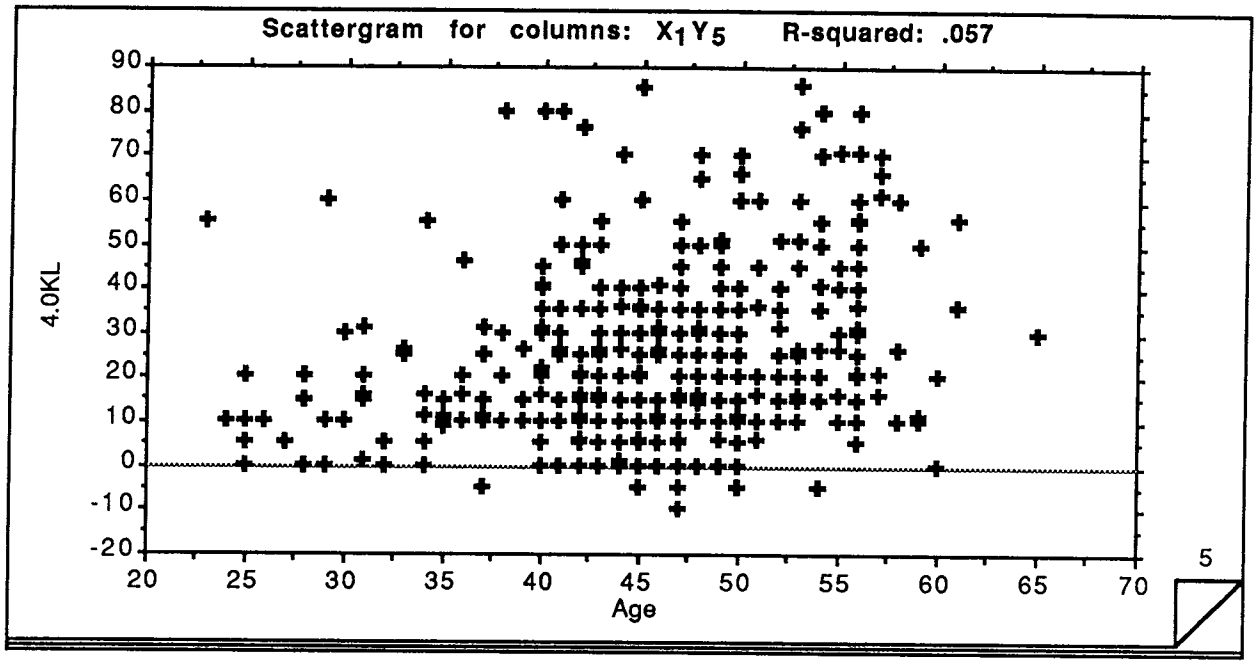
Ordinate: Hearing level in dB

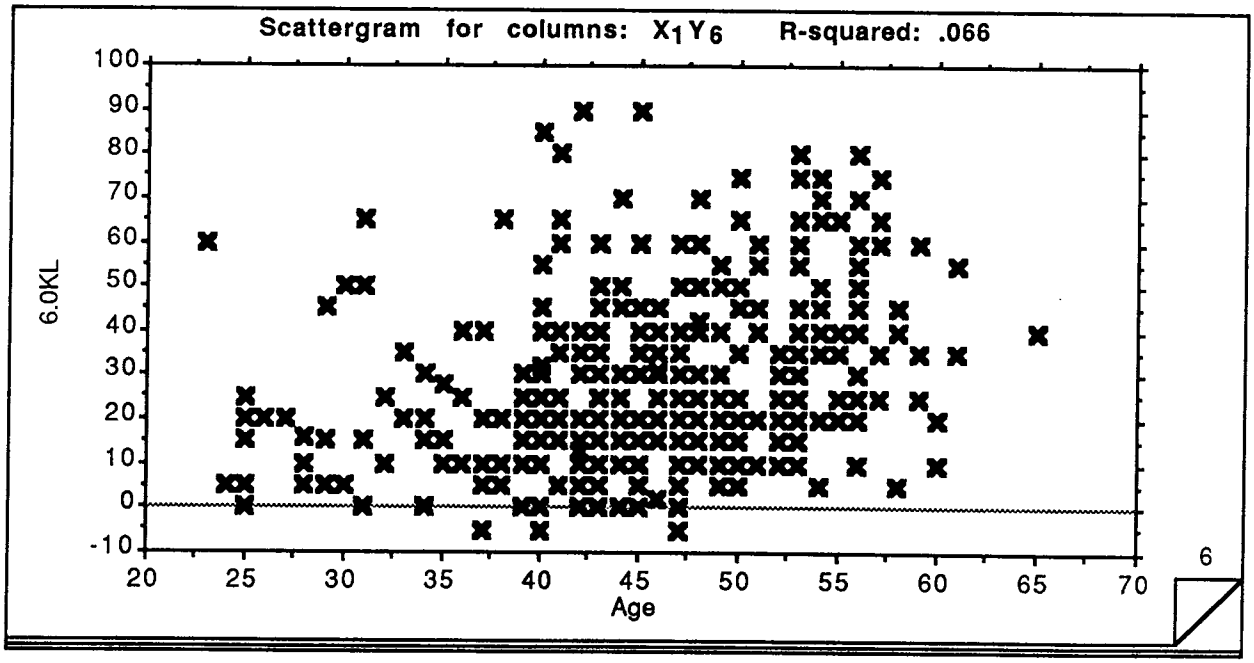
Abscissa: Age of subject

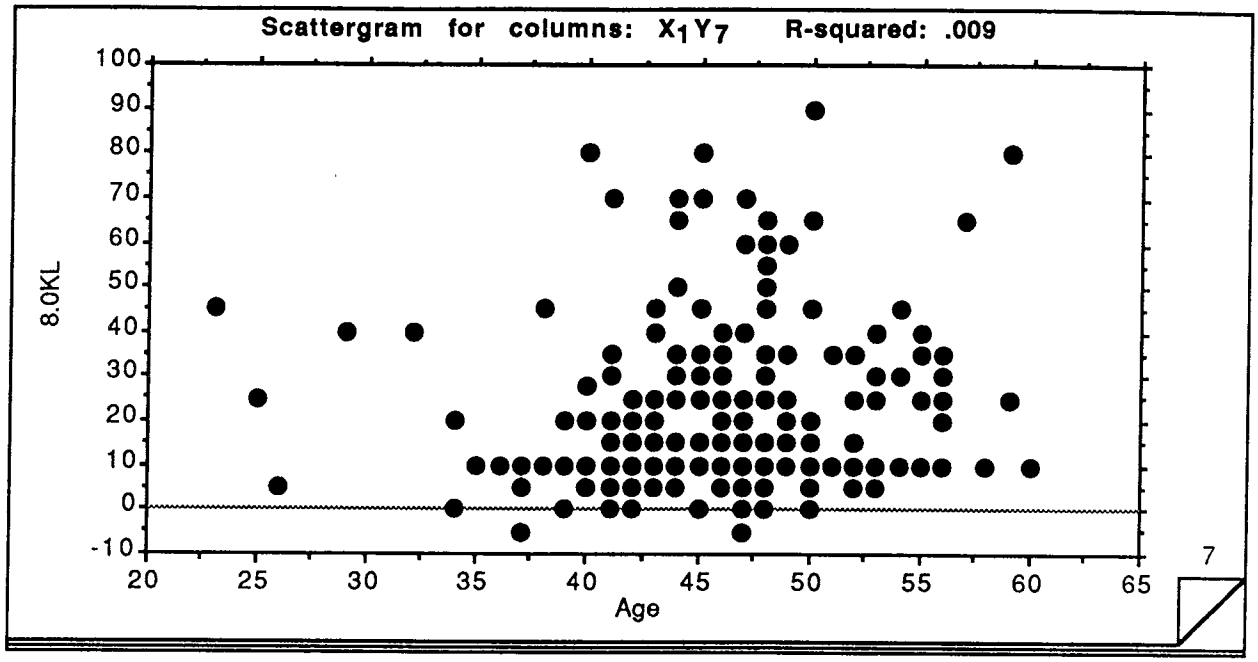
Note: each graph represents a single frequency.


Scattergram for columns: X1 Y3 R-squared: .046
2.0KL
70
60
50
40
30
20
10
0
-10
-20
20 25 30 35 40 45 50 55 60 65 70
Age
3


Scattergram for columns: X1 Y4 R-squared: .061
3.0KL
90
80
70
60
50
40
30
20
10
0
-10
20 25 30 35 40 45 50 55 60 65 70
Age
4


Scattergram for columns: X1 Y5 R-squared: .057
4.0KL
90
80
70
60
50
40
30
20
10
0
-10
-20
20 25 30 35 40 45 50 55 60 65 70
Age
5


Scattergram for columns: X1 Y6 R-squared: .066
6.0KL
100
90
80
70
60
50
40
30
20
10
0
-10
20 25 30 35 40 45 50 55 60 65 70
Age
6


Scattergram for columns: X1 Y7 R-squared: .009
100
90
80
70
60
50
40
30
20
10
0
-10
8.0KL
20
25
30
35
40
45
50
55
60
65
Age
7